Woodbury, Merrill, Patten, & Woodbury

AIR ENGINE

COMPANY.

JUNE, 1889.

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AIR ENGINE COMPANY.

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CAPITAL STOCK, $1,000,000.

10,000 SHARES.

2000 SHARES PREFERRED STOCK.

8000 SHARES COMMON STOCK.

DIRECTORS.

JAMES A. WOODBURY. JOSHUA MERRILL. GEORGE PATTEN.

E. FRANK. WOODBURY. GEORGE A. KEELER.

JAMES A. WOODBURY, *President.* HIRAM M. GOODRICH, *Clerk.*

JOSHUA MERRILL, *Treasurer.* E. FRANK. WOODBURY, *Constructing Engineer.*

Counsel for the Company.

CHARLES C. MORGAN, 32 Pemberton Square, Boston.

OFFICES.

No. 2 Goodrich Block,
NASHUA, N. H.

No. 8 Exchange Place,
BOSTON, MASS.

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THE ENGINE

Is Covered by Patents, and applications for Patents,

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PATENTS GRANTED BY THE UNITED STATES OF AMERICA.

No.	228712.	Dated	June	8,	1880.	No. of Claims,		24
No.	228713.	Dated	June	8,	1880.	No. of Claims,		10
No.	228714.	Dated	June	8,	1880.	No. of Claims,		7
No.	228715.	Dated	June	8,	1880.	No. of Claims,		7
No.	228716.	Dated	June	8,	1880.	No. of Claims,		20
No.	228717.	Dated	June	8,	1880.	No. of Claims,		6
No.	289484.	Dated	Dec.	4,	1883.	No. of Claims,		3
No.	289485.	Dated	Dec.	4,	1883.	No. of Claims,		1
No.	324060.	Dated	Aug.	11,	1885.	No. of Claims,		9
No.	324061.	Dated	Aug.	11,	1885.	No. of Claims,		17
No.	324062.	Dated	Aug.	11,	1885.	No. of Claims,		11
No.	325640.	Dated	Sept.	1,	1885.	No. of Claims,		11
No.	327748.	Dated	Oct.	6,	1885.	No. of Claims,		3
No.	331359.	Dated	Dec.	1,	1885.	No. of Claims,		3
No.	331360.	Dated	Dec.	1,	1885.	No. of Claims,		2
No.	331361.	Dated	Dec.	1,	1885.	No. of Claims,		9
No.	336093.	Dated	Feb.	16,	1886.	No. of Claims,		5
No.	404731	Dated	May	28,	1889.	No. of Claims,		14

TREATISE.

In submitting this treatise we trust that the presentation of this subject will command the attention of all users of motive power.

Appended to the treatise will be found a series of illustrations; the testimonials of the firm of Messrs. Hancock & Allen, who have used one of our experimental engines in the driving of their works at Winchendon, Mass., for five years; the Expert Report of George H. Barrus, relative to a 35 Horse Power Engine on exhibition at the works of the Downer Kerosene Oil Co., at South Boston; the opinions of several Engineers as to the value of the Engine; and quotations from various authorities, with explanatory notes.

Any information concerning our engine, we will with pleasure impart.

JAMES A. WOODBURY.
JOSHUA MERRILL.
GEORGE PATTEN.
EDWARD F. WOODBURY.
Inventors.

BOSTON, 1889.

Superiority of the Engine.

The essential features of our engine are a heater, regenerator, and cooler, which three in combination are termed a reverser. The engine illustrated is composed of two reversers and two double acting working cylinders. It is not an exhausting engine, therefore, it has neither admission nor exhaust valves. It is claimed to be the best motor ever produced, for the following reasons:—

It is absolutely safe.

It is simple in construction.

It is noiseless in operation.

It is durable and well arranged in all its parts.

It is constant in its speed.

It is made from improved designs and new patterns.

It is made of the best materials, in the most workmanlike manner.

It is economical in its operation, requiring one-half less fuel than any other engine.

It is interchangeable in all its wearing or working parts, therefore, duplicate parts can be immediately supplied.

It is perfectly lubricated at less expense than any other engine, requires the minimum amount of attention, it occupies less room, and it costs no more than a steam, gas, or any other style of engine plant of the same power and workmanship.

The expense to the inventors in working up the engine to its present perfected state, has been the expenditure of $150,000. in cash, and twelve years of their time. It may be properly stated at this time, that our action in delaying the introduction of our engine has been the subject of criticism; but, it has been deemed advisable by us, though at great personal present loss and discomfort to perfect the engine at our expense, rather than at the expense of the public. The engines made by us to-day are more than twice as practical, durable, and economical as the engines made six years ago, nevertheless, the engine sold to Ozro Hancock, Esq., made about six years ago, has given him and his successors, Messrs. Hancock & Allen, the greatest of satisfaction during a run of five years. See appended testimonial.

CONSTRUCTION.

The illustrations, represent our 35 Horse Power Engine. Figure 1 is an elevation, figure 2 is a plan, and figure 3 is a vertical sectional view of one reverser and working cylinder. The reversers are in duplicate, so also are the working cylinders.

Each reverser is provided with a reverser heater, placed within a furnace; a regenerator, composed of wire cloth of great superficial area, extending from the cooler to the bottom of the reverser heater; a cooler, composed of a large number of thin copper tubes, which are surrounded by water; and a displacer piston, having metallic packing rings, and adapted to reciprocate within the cooler. Each working cylinder is provided with a working piston having metallic packing rings. Each reverser is connected by means of pipes with the working

cylinders, as follows: — The hot chamber below the displacer piston is connected with the bottom of the working cylinder directly opposite; and the cold chamber above the displacer piston is connected with the top of the working cylinder diagonally opposite.

The means employed of converting the reciprocating motion of the pistons into a rotating motion are all of a common type.

A small single acting air pump, having a leather packed piston, is operated by an eccentric fastened to the main shaft. This pump is used, *first;* to compress the air to the initial pressure required, *second;* to maintain the initial pressure so attained, which is subjected to loss by leakage around the piston rods, which are packed in a very cheap, durable, and efficient manner, by means of cup-shaped leather packings.

The regulation of the speed of the engine is obtained by a balanced equalizing valve of simple construction, placed in an equalizing pipe which connects the top of the working cylinders together. The valve being operated by a common centrifugal governor.

OPERATION.

The power produced is due to the energy exerted upon the working pistons, by the alternate raising and lowering of the temperature of the same mass of air within the reversers.

When sufficient heat has been imparted to the reverser heaters, by the combustion of any kind of fuel within the reverser furnaces, the engine may be started by the use of compressed air (previously compressed into a small reservoir) admitted into the engine in an alternate manner, similar to the starting of a Corliss engine, by means of starting valves, (two common lever or globe valves). This method of starting is employed in engines of large sizes, or when it is desired to start an engine under a load. Engines of small sizes may be started as above, or by the use of a starting lever applied to the rim of the fly wheel, or by giving the fly wheel a one-half turn.

The cooling medium used is any kind of water, or a blast of air circulated through the coolers. A very small quantity of water is required, and the same body of water may be used over and over again.

DETAILED DESCRIPTION OF OPERATION.

In the operation, the alternate raising and lowering of the temperature of the same mass of air is accomplished as follows: — In the upward stroke of the displacer piston, the mass of air in the cold chamber above the piston is forced. *First*, through the cooling tubes, in its downward passage, through which the temperature of the air is not materially changed. *Second*, the air enters the regenerator, and in its passage through the same it absorbs heat which has been imparted to the regenerator. *Third*, the air then passing over the heated surface of the reverser heater, thereby becoming further heated, enters the hot chamber below the displacer piston.

The temperature of the air in the cold chamber is about 120° F., and the temperature of the air in the hot chamber is about 600° F.

In the downward stroke of the displacer piston, the mass of air is forced. *First*, to the regenerator. *Second*, the air enters the regenerator, and in its passage through the same, it deposits thereon the greater portion of its heat. *Third*, through the cooling tubes, where its

temperature is reduced to about 120° F., and then into the cold chamber above the displacer piston. Therefore, at each upward and downward stroke of the displacer piston, the temperature of the same mass of air is alternately raised and lowered. The reversers being in duplicate, it is obvious that the same alternate raising and lowering of the temperature of the displaced air would take place in one reverser as in the other; but, at opposite times; that is to say, both displacer pistons being operated by the reverser beam, whenever one displacer piston is making its upward stroke, the other displacer piston is making its downward stroke. It is therefore evident, that when the displaced air in one reverser is being heated, the displaced air in the other reverser is being cooled.

The alternate raising and lowering of the temperature of the displaced air, (in both reversers) generates a power in accordance with the well-known laws of the expansion of gases, which power is developed by the working cylinders, as follows:—While one displacer piston is making its upward stroke, and is heating and expanding the displaced air, thereby producing a pressure which is exerted against the bottom of the working piston of the working cylinder directly opposite the reverser, and against the top of the working piston of the working cylinder diagonally opposite; the other displacer piston is making its downward stroke, and is cooling and contracting the displaced air, thereby reducing the pressure against the bottom of the working piston, of the working cylinder directly opposite the reverser, and the top of working piston of the working cylinder diagonally opposite. Thus each working piston is subjected to differential pressures, which are alternately reversed as the displaced air is alternately heated and cooled. Thus a power is exerted to cause the working pistons to have a reciprocating motion, which is changed to a rotary motion by means of the working cylinder beam and its connected parts to the main shaft and the fly wheel, from which the power may be taken off by a belt. A portion of the power developed is absorbed in the friction of the engine, and a portion is used to operate the displacer pistons, by means of a reverser crank, reverser connecting rod, side lever, trunnion, reverser beam, and connected parts. The engine is designed to run on an initial pressure (per gauge) of air of about forty-five pounds, at a speed of 115 revolutions per minute.

At each revolution of the engine the quantity of air (compressed) required to supply the initial pressure and leakage is pumped, preferably, into a reservoir, from which the air passes through check valves (one check valve for each working cylinder) into the engine, and a lever safety valve is attached to the reservoir as a means of controlling the initial pressure of the air used.

SPECIAL ADVANTAGES DUE TO CONSTRUCTION.

The working pistons being connected by means of a beam, are therefore counterbalanced. The displacer pistons are counterbalanced in a like manner. The temperature of the surfaces against which the metallic packing rings of the displacer pistons slide, is about 90° F., and the temperature of the surfaces against which the metallic packing rings of the working pistons slide, is about 180° F. All the pistons operating in vertical lines wear the cylinders evenly, and by reason of their vertical positions they require the minimum amount of set to the packing rings, and the consequent friction of the pistons is reduced to the smallest amount possible. Therefore, for the reasons above given, and also that there is no exhaust, the amount of oil required to lubricate the pistons is reduced to a minimum quantity.

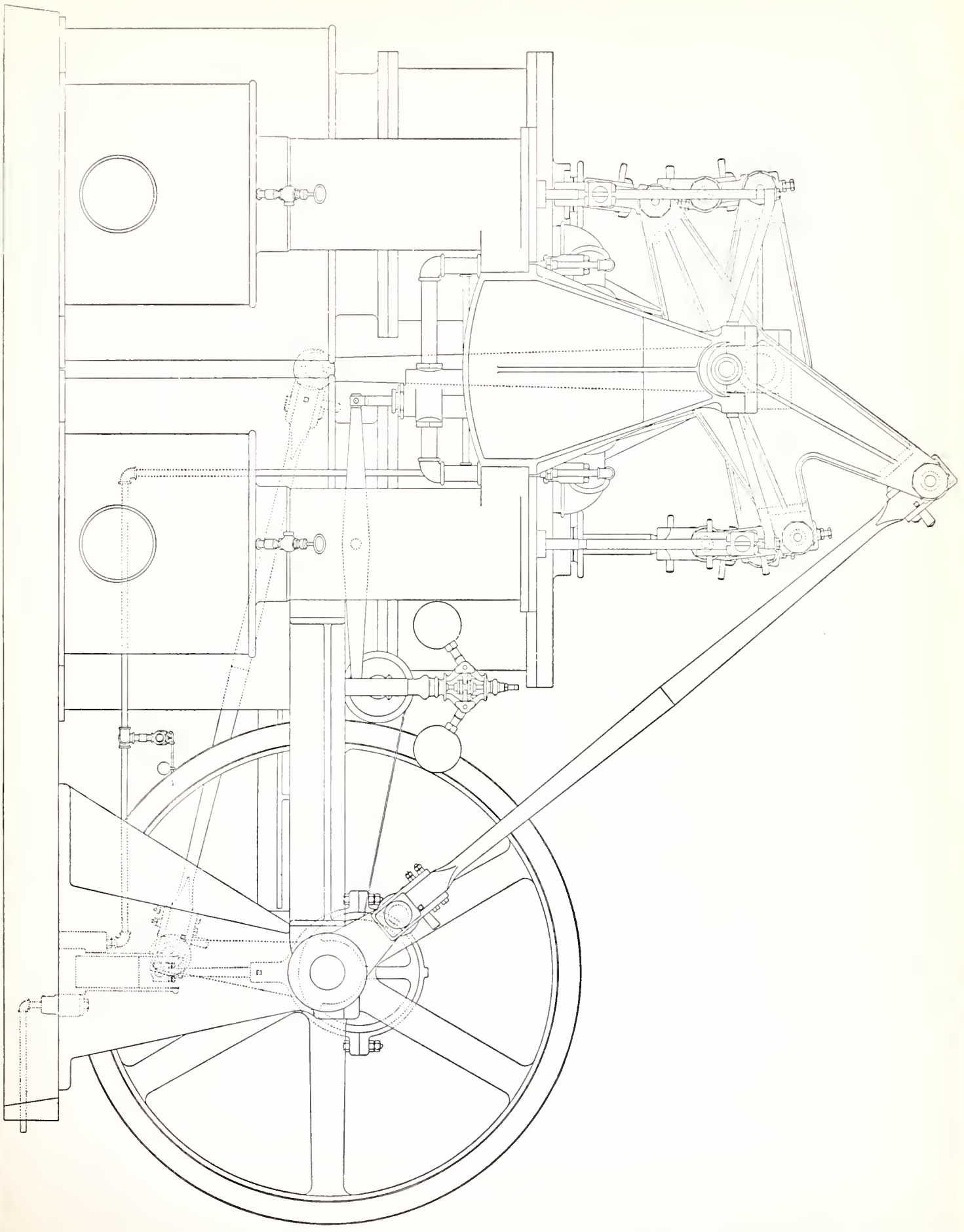

FIGURE 1

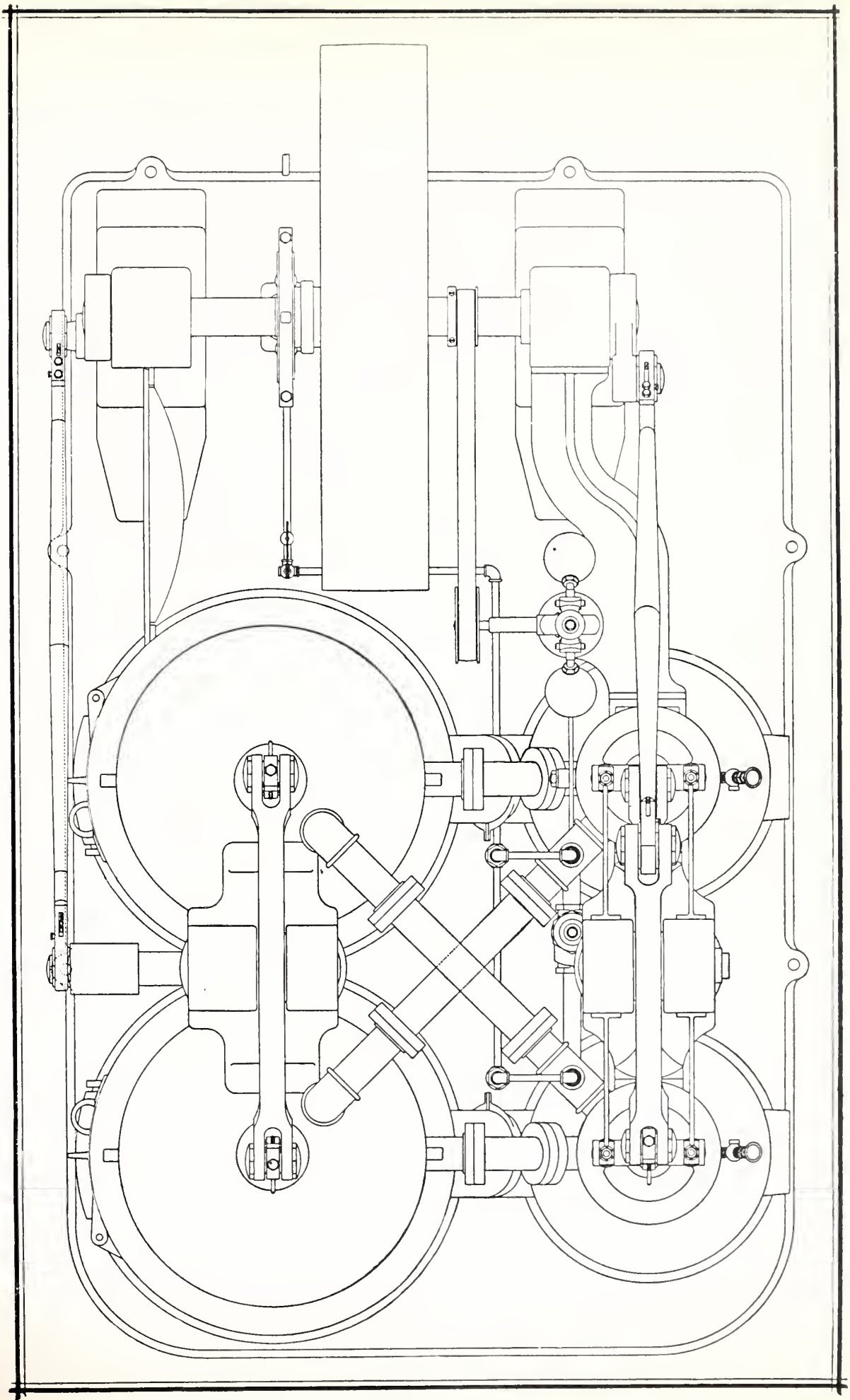

FIGURE 2.

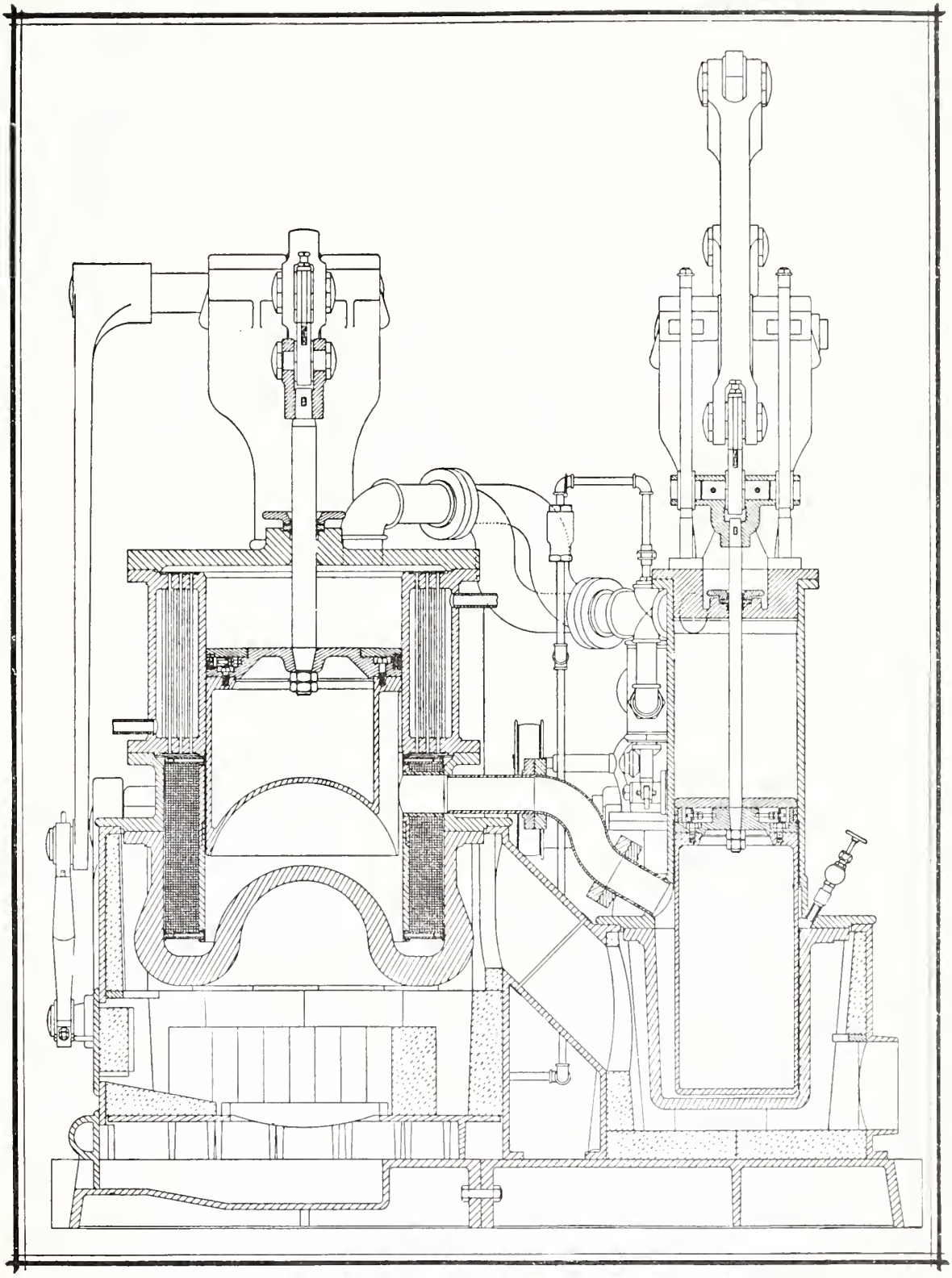

FIGURE 3.

AIR ENGINE TEST.

By Geo. H. Barrus, M. E.

Mr. JOSHUA MERRILL, Treasurer,

OF THE

Woodbury, Merrill, Patten, & Woodbury Air Engine Co.,

8 Exchange Place, Boston, Mass.

Dear Sir:

Having made at your request a series of tests on the No. 13 Woodbury, Merrill, Patten, & Woodbury Air Engine, at your works in South Boston, the object of which was to determine the economy as to consumption of fuel with which the engine works, I beg to submit the following table, a brief summary of the principal results of the same. A description of the engine, and the method of conducting the tests, together with a full record of the results, is given in a detailed report, which I will submit at an early day.

On all the tests except the last, the principal load on the engine, consisted of a No. 35 Sturtevant Exhausting Fan, with 72 inch case, which makes 535 revolutions per minute when the engine makes 110 revolutions per minute. On the last test, the principal load consisted of the same fan, and in addition, a Sturtevant Fan, with 60 inch case, No. 123, which made about 625 revolutions per minute. The friction of the engine was determined by subtracting the average power absorbed by a Prony Brake, applied to the fly-wheel, from the indicated Horse Power developed at the same time, on the occasion of supplementary tests, a part of which were made March 7th, and a part, March 22nd, the number of these tests being fourteen. The average Indicated Horse Power was 31.18, and the average Brake Horse Power, 19.92

It appears from the table, taking the test of March 23rd as a proper indication of the performance of the engine, that the amount of coke used in a ten hours run, including the wood and coke required to start the fire, beginning with a cold engine, was 1.91 lbs. per Indicated Horse Power per hour, and 2.98 lbs. per Brake Horse Power per hour. On the same test, for a period of 6¼ hours, after the engine had attained its normal conditions of work, the quantity of coke consumed was 1.54 lbs. per indicated Horse Power per hour, and 2.37 lbs. per Brake Horse Power per hour. During the test of March 6th, the quantity of water which passed through the Coolers amounted to an average of 3612 lbs. per hour, which is equivalent to 7.2 gallons per minute. This water was supplied at a temperature of 36 degrees, and discharged at a temperature of 102.8 degrees.

I do not regard these results as the best that can be obtained from the engine, for there is a considerable loss of heat from the unprotected exterior surfaces of the Furnaces, due to radiation, which can easily be prevented by the use of suitable covering.

Taking the results as they stand, however, the consumption of fuel per Effective Horse Power transmitted through the belt, is not more than one-half of that required for the best non-condensing steam engines of small power, which are commonly used.

It appears to me that the engine, in its present shape, may be successfully placed on the market, with the assurance of satisfactory results in practical operation, and I believe that its economy in the consumption of fuel and entire safety will commend it to any person requiring motive power.

In view of the very large improvement that has already been made in the economy of the engine, and in view of the evident losses which have been referred to, which are still going on, it seems quite probable that an engine of this type can be made which will develop an indicated Horse Power on a consumption of 1 lb. of coal per hour; measuring the coal during a period beginning with the fires in a normal condition, and ending with the fires in the same condition. This is one-third less than the results of the test of March 23d, giving 1.5 lbs. of coal per indicated Horse Power per hour.

I am, Faithfully yours,

GEO. H. BARRUS,

Expert and Consulting Steam Engineer,

No. 95 Milk St., Boston.

March 29, 1889.

1. KIND OF FUEL.	*GAS HOUSE COKE.				Connellsville Creek Cumberland Co. I.
2. Date of Test. 1889.	Mar. 5.	Mar. 6.	Mar. 23.	Mar. 23.	Mar. 25.
3. Duration . . . . hrs.	7.	8.25	10.	6.25	5.
4. Condition of fire at beginning and end.	Normal.	Begin with New Fire. End with Fire burned out.	Begin with New Fire. End with Fire burned out.	Normal.	Normal.
5. Weight of dry fuel burned, including 4-10 of weight of wood used for lighting fire . . . . . lbs.	342.	453.6	601.6	314.	262.
6. Weight of dry fuel burned per hour lbs.	48.9	55.	60.2	50.	52.5
7. Indicated H. P. developed by engine, I.H.P.	30.16	29.68	31.45	32.38	32.43
8. Revolutions per min.	113.1	112.4	112.5	113.6	108.4
9. Fuel burned per I.H.P. per hour lbs.	1.62	1.85	1.91	1.54	1.62
10. Fuel burned per Brake H.P. per hour, assuming friction of 11.26 H.P.	2.59	2.99	2.98	2.37	2.48

*On the test of March 5th, the coke when fired, contained 20% of moisture, and on that of March 6th, 14.2% of moisture, determined by drying samples.

On the test of March 23rd, the coke when fired, was dry.

TESTIMONIALS.

Established 1845.
HANCOCK & ALLEN,
Successors to OZRO HANCOCK.

MR. JOSHUA MERRILL, *Treasurer*, WINCHENDON, MASS., March 5th, 1889.
Woodbury, Merrill, Patten & Woodbury Air Engine Co.,
8 Exchange Place, Boston, Mass.

DEAR SIR, — Having for the past five years used one of your Air Engines, I gladly certify that it has proved most excellent, in every respect, as a motor. The consumption of fuel has never exceeded 350 lbs. per day, including the starting fires. The engine requiring very little attention, the engineer being able to do at least three-quarters of a day's work at tools, besides caring for the engine. The power being steady and uniform, no apprehension of danger to trouble us, and, in short, I consider it a most valuable and reliable motor. Since putting in our new engine of an improved make, we are using 250 lbs. only of bituminous coal, with a small amount of spent tan bark in combination. This includes the starting coal, or the entire consumption for the day, the engine indicating about 14 Horse Power, and, to drive our entire machinery, requiring at least 10 delivered Horse Power. The engine runs beautifully; steady motion; regulates as closely as the best steam engine, and is most satisfactory in every particular. I feel you will have great success in the sale of this engine to all people requiring power, and I wish you the success so fine an invention is worthy of.

I am, respectfully yours,

JOHN HANCOCK,
Of the firm of Hancock & Allen.

MR. JOSHUA MERRILL, *Treasurer*, 31 Milk Street, BOSTON, April 6, 1889.
Woodbury, Merrill, Patten & Woodbury Air Engine Co.,
8 Exchange Place, Boston, Mass.

DEAR SIR, — In reply to your inquiry, I have seen the various air engines invented by yourself and associates, and have taken note of the continued improvements added from time to time for several years, and therefore am able to express my confidence in their practical operation, safety from explosions, and economy in fuel.

Yours very truly, C. J. H. WOODBURY

M. C. BULLOCK, *Pres.* GEO. WOODLAND, *Treas.* O. H. BLANKE, *Sec'y.* J. S. LANE, *Gen'l Supt.*
M. C. BULLOCK MANF'G CO.,
Phenix Building, No. 138 Jackson Streef.
Works: Lake St. and Talman Avenue.

MR. JOSHUA MERRILL, *Treasurer*, CHICAGO, U. S. A., April 15, 1889.
Woodbury, Merrill, Patten & Woodbury Air Engine Co.,
8 Exchange Place, Boston, Mass.

DEAR SIR, — Replying to your favor of the 11th, I beg to acknowledge, not only your very kind letter, but also the report of the tests made by Geo. H. Barrus, on the Woodbury, Merrill, Patten & Woodbury Air Engine. I have examined the tests very carefully, and am more than pleased with the results, and I wish to congratulate you most heartily upon the advance which you have made in perfecting this remarkable engineering problem.

With kind regards, and wishing you the success which you so richly deserve, I am,

Yours very sincerely, M. C. BULLOCK, *Pres't.*

D. M. Weston, *Pres.* Wm. O. Lincoln, *Treas.* Benj. F. Radford, *Gen. Mang.*

THE AMERICAN TOOL & MACHINE CO.,

84 Kingston Street,

Mr. Joshua Merrill, *Treasurer*, Boston, Mass., April 25, 1889.

Woodbury, Merrill, Patten & Woodbury Air Engine Co.,

8 Exchange Place, Boston, Mass.

Dear Sir, — Having carefully read the report, by Mr. Barrus, of several trials of your engine, made for the purpose of ascertaining its economy in the consumption of fuel, and having seen this engine in operation, I am quite of the opinion that it is to be the motor of the future, where not exceeding 75 to 100 Horse Power is required.

Yours very truly,

Benj. F. Radford,

General Manager The American Tool & Machine Co.

THE TAUNTON LOCOMOTIVE MFG. CO.

Wm. R. Billings, *Agent and Treasurer.*

Mr. Joshua Merrill, *Treasurer*, Taunton, Mass., April 27, 1889.

Woodbury, Merrill, Patten & Woodbury Air Engine Co.,

8 Exchange Place, Boston, Mass.

Dear Sir, — In reply to your request for an expression of our views upon certain points connected with your Air Engine, we take pleasure in saying that we have examined on several occasions, and with considerable care, the engine now in operation at South Boston; that we believe that this engine marks an important advance in the progress of the Air Engine towards practical perfection: that the economy of fuel, indicated by the tests made by Mr. Barrus and others, is remarkable, and that we are ready to make arrangements with you for the construction of your Air Engine, of such sizes as you may name and from such patterns and drawings as you may furnish.

Yours very truly,

Taunton Locomotive Mfg. Co.

By Wm. R. Billings, *Agt. and Treas.*

Col. Franklin Fairbanks, *Prest.* E. R. Whitney, *Vice Pres.* P. F. Hazen, *Sec'y*, St. Johnsbury, Vermont.
W. P. Fairbanks, *Treas.* Warren S. Hill, *Ch. Ex. Com.* L. A. Milbank, *Mgr.*, 161 Franklin St., Boston.

STANDARD ELECTRIC COMPANY, of Vermont.

(Whitney System.)

Manufactured by the E. & T. FAIRBANKS & CO., St. Johnsbury, Vt.

Mr. Joshua Merrill, *Treasurer*, Boston, Mass., April 30, 1888.

Woodbury, Merrill, Patten & Woodbury Air Engine Co.,

8 Exchange Place, Boston, Mass.

Dear Sir, — My continued absence from Boston has alone prevented my calling on you during the past two weeks. There are several parties who are interested in the reports of the tests made on your engine, and it is my intention to accompany them when they make their inspection. If they see the engine as I have seen it, there is no doubt about their verdict. It is hard to convince anyone that there is an air engine of any practical use, that is, an engine capable of delivering any considerable amount of power, — 20 or 30 Horse Power, for instance. Seeing is believing, however, and the most skeptical must give way after investigating your motor. Proving as you do that a Horse Power may be *delivered* with an expenditure of 2.37 lbs. of coal per hour, and that result accomplished without boiler or steam, you must attract the attention of the power using public. For use in hotels and apartment houses, where electric lighting machinery or ventilating apparatus may be required, your engine is particularly well adapted. Again, in locations where the use of steam is impossible on account of lack of boiler room, you stand ready to supply the situation. I am convinced that the Air Engine, in the present form, constructed by your company, is a motor of decided value, not alone on account of its economy but also on the score of safety.

Very truly yours,

Wm. C. Woodward, *Electrical Engineer.*

GRANT LOCOMOTIVE WORKS.
New York Office, 43 Wall St.

MR. JOSHUA MERRILL, *Treasurer*, PATERSON, N. J., April 16, 1889.
Woodbury, Merrill, Patten & Woobury Air Engine Co.,
8 Exchange Place, Boston, Mass.

DEAR SIR, — Yours of 11th inst., with report of the tests of your Air Engine, by Mr. Barrus, M.E., to hand. I have read it with interest, and can see no reason why your engine should not have a large sale as soon as you are ready to put it on the market. Respectfully, W. W. EVANS, *Sup't.*

THOMSON-HOUSTON ELECTRIC CO.
ELECTRIC LIGHTING AND POWER.
Works, Lynn, Mass. Principal Office, 620 Atlantic Ave., Boston. Western Office, 148 Michigan Ave, Chicago.

MR. JOSHUA MERRILL, *Treasurer*, BOSTON, May 3, 1889.
Woodbury, Merrill, Patten & Woodbury Air Engine Co.,
8 Exchange Place, Boston, Mass.

DEAR SIR, — In accordance with your request, I desire to submit my opinion regarding your new Air Engine. I have been very much interested in reading the report of Mr. Barrus in regard to the test made on same by him, and was largely influenced by reading these reports to go and make a personal examination of the 30 Horse Power Engine now completed.

It is my opinion, based upon some little experience in steam engineering, that in this engine you have made a decided step in advance on the subject of air engines. I am confident that in this you have a perfect, practical, and exceedingly economical engine; and should you decide to construct a 100 Horse Power for your first size, you may consider that you have an order for one from this company.

Very truly yours,
ENGINEERING DEPARTMENT THOMSON-HOUSTON ELECTRIC CO.
H. C. PATTERSON, *Elec.*

MR. JOSHUA MERRILL, *Treasurer*, BOSTON, May 3, 1889.
Woodbury, Merrill, Patten & Woodbury Air Engine Co.,
8 Exchange Place, Boston, Mass.

DEAR SIR, — In the year 1877, as manager of the Nashua Iron & Steel Co., I made an arrangement with you to manufacture the first experimental engine, to be propelled by means of the heating and the cooling, in rapid succession, of the air confined within the cylinders and "heater" of the machine. So much success was secured at that time as to give me an earnest of very promising results to come, and consequently, I have, from time to time, become somewhat familiar with the successive improvements you have added to the engine. On my last visit to the machine, a few days ago, I was more than ever impressed with the perfection of the motor, its simplicity, its reliable efficiency as to power, its smoothness and regularity of motion, and the ease with which it is managed. I am convinced that you have made very great strides towards a safe, efficient, and reliable means of motion, and have no doubt the engine will, in large degree, supersede the use of steam as a means of mechanical power. I hope your perseverance and large outlay will be fully rewarded.

Truly, &c., MOSES A. HERRICK.

WRIGHT ELECTRICAL ENGINEERING CO.,
74 FEDERAL STREET.
ALEX. P. WRIGHT, *Managing Director.*

MR. JOSHUA MERRILL, *Treasurer*, BOSTON, MASS., U. S. A., May 4th, 1889.
Woodbury, Merrill, Patten & Woodbury Air Engine Co.,
8 Exchange Place, Boston, Mass.

DEAR SIR, — I was much interested during my visit to see your Air Engine, and have given it considerable thought since. If it will come up to the claims made for it, and I believe it will do so and more, when suitable sizes are ready for the market, the field for its application in Electric Lighting will be very wide, and it will undoubtedly come into use to a large extent for this purpose.

Yours truly, ALEX. P. WRIGHT,
Expert Consulting and Electrical Engineer.

Quotations from various Authorities with Explanatory Notes.

The theoretical advantages of air as a safe and economical agent for converting heat into power have long been recognized by scientists and mechanicians; but efforts, to use it practically, have been attended, hitherto, with such great difficulties, as to prevent its general adoption as a motor.

But, notwithstanding the obstacles have appeared excessive, the most eminent authorities on mechanics have been confident that air is destined, to supersede steam.

Appleton's Cyclopædia of Applied Mechanics, vol. I., page 620, published in 1880, states:

"The engines that have just been described are necessarily limited to comparatively low pressures, and hence must be very bulky when designed to develope considerable power. This limitation is an essential condition of their design, because the original pressure of the air which is compressed and heated is that of the atmosphere. If, however, the working air be confined in the machine, and originally compressed to a high pressure, this difficulty disappears. Thus, suppose it is found practicable to maintain a temperature in a given air-engine sufficient to double the original pressure of the air. Then, if the air were admitted at the pressure of the atmosphere, the available pressure, after heating, would be about 15 lbs. per square inch. But if the supply of air were drawn from a reservoir, in which the pressure was 60 lbs. per square inch, the effect of increasing the temperature to the same point as in the former case would be to double the original pressure, making 120 lbs. per square inch. It seems strange that the majority of inventors should have ignored this significant principle."

We employ this principle of using air compressed to a pressure of 60 lbs. per square inch.

And on page 623 the following occurs:

"It has been predicted by more than one prominent engineer that the steam engine will yet be superseded by the air engine."

In a work by a well known writer, John Bourne, entitled "Recent Improvements in the Steam Engine," published in London, in 1874, on page 330, he states:

"The wasteful character of the steam engine as a source of motive power, has now become so widely known that public attention has been directed with more ardor than heretofore, to the discovery of expedients for its supersession. Of these alternative expedients, the most promising seems to be some form of air or gas engine. But all the air and gas engines, heretofore devised, labor under this radical defect, that only low pressures can be employed in them, and hence only a portion of the energy of the heat can be transformed into power. So soon as this fault shall have been corrected, without the introduction of other sources of loss, the steam engine will be superseded; and there are good grounds for concluding that this result is not far distant, but will soon be achieved."

We have remedied this defect, without the introduction of other sources of loss.

Knight's American Mechanical Dictionary, published in 1874, vol. I, page 35, states:

"In this engine the air received heat at the temperature of 650° Fah., and discharged the lost heat at that of 150° Fah. The efficiency of a theoretically perfect engine, with those limits of temperature, would be 0.45, and its consumption of coal 0.73 of a lb. per horse-power per hour.

The actual consumption of coal per horse-power per hour was about 2.2 lbs., being three times the consumption of a theoretically perfect engine, and corresponding to an actual efficiency of 0.15 or one-third of the maximum theoretical efficiency.

The following is a comparison of the consumption of bituminous coal of specified quality, per horse-power per hour:

1. For a theoretically perfect engine, working between such limits of temperature as is usual in a steam engine, 1.86 lbs.
2. For a double acting steam engine, impelled to the utmost probable extent, 2.50 lbs.
3. For a well constructed and properly worked ordinary steam engine, on an average, 4.00 lbs.

Referring to above, especially to paragraph 3, *we direct your attention to the fact, that as per test of George H. Barrus, herewith submitted, the consumption of coal per horse-power per hour of our engine is but* 1.54 *lbs.*

Science has thoroughly demonstrated the theoretical economy of heat which results from the use of the regenerator. Rankine in his "Manual of the Steam Engine and other prime movers," published in London, in 1876, states on page 353:

"By thus storing and re-storing a certain quantity of heat, the alternate lowering and raising of the temperature of the air is effected without the expediture for that purpose of any heat from the furnace, except such as is requried to supply the waste of heat that occurs in the regenerator; that waste, according to experiment, being from *one-tenth* to one *one-twentieth* of the whole quantity of heat required to raise the temperature of the air at each stroke."

Our engine is provided with the most perfect regenerator ever made, by the use of which, we obtain the highest economical results.

Engines of the following sizes will be constructed and put upon the market with as little delay as possible:—

No. 5. Five Horse Power.

No. 10. Fifteen Horse Power.

No. 15. Thirty Five Horse Power.

No. 20. Sixty Horse Power.

No. 25. One Hundred Horse Power.

The rapid advance lately made in the economy of this engine has convinced the inventors from the data they have developed, that there is no doubt but that engine number 25, and probably number 20, will run on 1 lb. of coal per Indicated Horse Power per hour, and 1.6 lbs. per Delivered Horse Power per hour.

A large number of orders for engines of various sizes, to be delivered as soon as they can be constructed, are already offered to the Company.